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Mr. Brown
(Return to Governor)

MERRIMACK VALLEY FLOOD CONTROL

DEFINITE PROJECT REPORT

FOR

LOWELL MASS.
LOCAL PROTECTION

MERRIMACK RIVER



CORPS OF ENGINEERS, U.S. ARMY

U.S. ENGINEER OFFICE

BOSTON, MASS.

9

Subject.....

Computation.....

Computed by.....

Checked by.....

Date.....

Memorandum: 2/20/39.
Telephone conversation with Mr.
Kirtfield of the State Hwy. Dept.
Cap 7800 - estimation \$0, regarding
status of new highway project
along N. side of Merriam R
through Rosemont Section.

The state highway estimated this
project at request of city authorities
and made rough estimates both
before and after the construction of
the spoil dikes. This not included
in the present program for
work and has no immediate
prospect of being included.

Mr. Kirtfield stated that in event
such a project should be built, the
roadway elevation would be placed
to such height as to form a dike
against flooding

F.S.B.

DEFINITE PROJECT REPORT, LOWELL, MASS.

LOCAL PROTECTION

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U. S. Engineer Office

Boston, Mass.

November 15, 1940

WAR DEPARTMENT
UNITED STATES ENGINEER OFFICE
3D FLOOR, PARK SQUARE BLDG.
31 ST. JAMES AVENUE
BOSTON, MASS.

November 15, 1940

Subject: Definite Project Report, Lowell, Mass. - Local Protection

To: The Chief of Engineers, U. S. Army, Through the Division
Engineer, North Atlantic Division, New York, N.Y.

1. Authority.- The project for local protection at Lowell, Mass., as described herein, is proposed as an element of the comprehensive plan for flood control reservoirs and related flood control works for the Merrimack River Basin authorized by the Flood Control Acts approved June 22, 1936 and June 28, 1938. The Flood Control Act of 1938 provides that, "The project for flood control in the Merrimack River Basin as authorized by the Flood Control Act approved June 22, 1936, is modified to provide, in addition to the construction of the system of flood control reservoirs, related flood control works which may be found justified by the Chief of Engineers."

2. Previous Investigations.- The investigations and studies upon which the authorized project for the Merrimack River Basin is based are described in House Document No. 689, 75th Congress, 3d Session.

3. Location and Description of Area Affected.- a. General. The proposed project is located on the left (north) bank of the Merrimack River in the city of Lowell, Middlesex County, Mass. The site is 39 miles above the mouth of the Merrimack River and 25 miles northwest of Boston, Mass. The area to be protected consists of about 120 acres of urban residential property with a population of approximately 5,000. The area, known locally as the Lakeview and Rosemont sections, is occupied by employees of industrial establishments in Lowell engaged principally in the manufacture of textiles, textile machinery, and boots and shoes. The total assessed valuation of the area to be protected is estimated to be between 2 and 3 million dollars.

b. Flood Situation. The greatest flood of record in this vicinity occurred in March 1936, when the area affected by the proposed project was flooded to depths ranging from 5 to 10 feet and total losses, direct and indirect, of more than a million dollars were suffered. Portions of the area were flooded again in September 1938, the second largest flood of record. The average annual losses for the area have been computed to be about \$40,000.

c. Related Flood Control Projects. The status of other flood control projects forming a part of the comprehensive plan for flood control in the Merrimack River Basin is shown on Plate 1. Two reservoirs, Franklin Falls and Blackwater, are under construction and three additional reservoirs, Hopkinton-Everett, West Peterboro, and Mountain Brook, have been proposed. The effects of these reservoirs, as well as of channel improvements in the Merrimack River through this section of Lowell completed in 1938 with E.R.A. funds, have been taken into account, as described in the following paragraph, in determining the required grade for the local protection project. There are no other flood control works, existing or proposed, which would affect the project proposed herein.

4. Definite Project Plan.- a. Work Proposed. The area to be protected is shown on Plate 2. During the course of channel improvements completed by the Department in 1938 with E.R.A. funds, assorted materials were excavated from the Merrimack River bed in this area and were deposited, in the form of spoil dikes, over much of the site of the work now under consideration. It is proposed to protect this area from flooding by providing an impervious blanket and drainage treatment for the existing spoil dikes, by constructing sheet piling walls, and by providing pumping facilities for the drainage of the two separate sections thus inclosed, as follows:

(1) Lakeview Section. Approximately 2,700 feet of dike work and 900 feet of sheet piling wall will be required in this section. A pumping station will be provided at the foot of West Street (see Plate 4). An interceptor sewer to the pumping station will be provided by local interests.

(2) Rosemont Section. Approximately 1,000 feet of dike work and 800 feet of sheet piling wall will be required for this section. One pumping station will be necessary at the foot of Beaver Street (see Plate 5). An interceptor sewer will be provided by local interests.

b. Design Flood. The maximum flood of record in this section (March 1936) was an outstandingly great flood, exceeding all previous floods in an official record of 90 years and an unofficial record of nearly 200 years by about 8-feet in stage and 65,000 c.f.s. or 60 percent in peak discharge. A flood 15 percent greater than the maximum of record would reach a stage only 2 feet higher. It was concluded, therefore, that the maximum flood of record would be adequate as a design flood for local protection in this area, taking into account the channel improvements already completed and the reservoir program under way and proposed. The required grade, therefore, has been selected to provide 3 feet of freeboard over the stage of the March 1936 flood as reduced by the comprehensive reservoir system and channel improvements. It is proposed also to maintain this grade for the sheet piling wall sections in order to make the protection

effective (by encroaching on the freeboard) for the design flood during the intermediate stage between the completion of the Franklin Falls and Blackwater Reservoirs now under construction and the completion of the remaining reservoirs in the program. A profile showing the adopted grade and the water surface of the design flood is shown on Plate 2.

5. Hydrology.- a. Drainage Area. (1) Lakeview Section. The drainage area in this section consists of 860 acres of urban land of varying degrees of development as follows (see Plate 3):

<u>Area No.</u>	<u>Area (acres)</u>	<u>Degree of Development</u>
A	250	Undeveloped, grass and brush cover. Drains principally into Area B, partly into C.
B	125	Undeveloped, swampy meadow. Drains into Area D sewer at southwest corner of Area B.
C	115	Limited residential development, sewered.
D	190	Residential development, sewered.
E	40	Undeveloped, no sewers.
F	140	Thickly settled, sewered.
Total 860		About 52% of total area is sewered.

The highest point of the drainage area is Elev. 260 at the northern extremity of Area A. The watershed slopes gently to the Merrimack River and has a long axis about 2 miles in length in a north-south direction. There are 4 combined storm and sanitary sewer outfalls in the Lakeview section, as follows:

<u>Type of Sewer</u>	<u>Location (See Plate 4)</u>	<u>Computed Capacity Flowing Full (c.f.s.)</u>
66" brick circle with submerged outfall	West Street	200
16" cast iron, with submerged outfall	Fulton Street	4
39"x26" brick oval	Broughton Avenue	31
18" Akron circle	Front Street	5
Total		240

Although the existing sewer system may be extended over the area in the future, it is unlikely that the trunk sewer capacity will be increased.

(2) Rosemont Section. The drainage area in this section consists of 70 acres of residential development all of which is served by combined storm and sanitary sewers (see Area G on Plate 3). There is one main or trunk sewer on Beaver Street, a brick oval 37"x25", and 4 small sewers from 12" to 24" in diameter serving the short streets that parallel Beaver Street. All sewers discharge into Beaver Brook.

b. Time of Concentration. The time of concentration for the 860 acres of the Lakeview section was estimated by assuming the time of concentration for the undeveloped areas and computing the time of travel of storm run-off through the sewer system of the other areas. The total time of concentration for the Lakeview section is conservatively estimated to be 60 minutes. The time of concentration for the 70 acres of the Rosemont section is estimated to be 15 minutes.

c. Storm Rainfall. There are no rainfall records for Lowell suitable for use as maximum precipitation rates for storms of the duration of 60 minutes and 15 minutes. The rainfall intensity data prepared by Yarnell and published in the United States Department of Agriculture publication No. 204 were used for this study. For comparison, the maximum hourly rainfall rates for an actual 36-year period at Boston, 25 miles from Lowell, are listed below for frequency periods corresponding to Yarnell's data.

Frequency in Years	Max. Rainfall in Inches Per Hour Yarnell's Data (for Lowell)		Max. Rainfall in Inches Per Hour for 36-Year Period at Boston (60 min. duration)
	Lakeview Section (60 min. duration)	Rosemont Section (15 min. duration)	
2	1.10	2.8	0.57
5	1.53	3.6	1.07
10	1.75	4.1	1.45
25	2.30	5.0	1.65

d. Storm Run-off. The storm run-off was computed using the formula $Q = A I R$, in which

Q = the rate of storm run-off, in c.f.s.

A = drainage area, in acres

I = percentage of imperviousness of the area

R = the average rainfall rate, in inches per hour

The percentage of imperviousness was estimated from an evaluation of the separate zones of the drainage area, as described in paragraph 5, with respect to the character and slope of the surface, the type

of development, relative proportion of lawns, gardens, roof surfaces, paved streets, etc. The adopted percentages of imperviousness are as follows:

(1) Zone	(2) Area (acres)	(3) Estimated Percentage of Imperviousness	(4) (2) x (3)
A	250	0.10	25.0
B	125	0.05	6.3
C	115	0.22	25.3
D	190	0.28	53.3
E	40	0.15	6.0
F	140	0.35	49.0
Composite % of imperviousness for Lakeview =			$\frac{164.9}{860} = 0.19$
Rosemont Section			
(Zone G)	70	0.30	

The theoretical amount of storm run-off to be provided for was computed from the foregoing data as follows:

Frequency in Years	Lakeview Section		Rosemont Section	
	Rainfall Rate in In./Hr.	Storm Run-off c.f.s.	Rainfall Rate in In./Hr.	Storm Run-off c.f.s.
2	1.10	180	2.8	59
5	1.53	250	3.6	76
10	1.75	286	4.1	86
25	2.30	376	5.0	105

e. Sanitary Sewage. The total population of the area protected is about 5,000, of which two-thirds are in the Lakeview section and one-third in the Rosemont section. Allowances of 2 c.f.s. and 1 c.f.s., respectively, are considered ample for sanitary sewage flow from these areas.

f. Dike Seepage. Allowances of 3 c.f.s. and 1 c.f.s., respectively, for the Lakeview and Rosemont sections were made for dike seepage. The foundation conditions and relative permeability of these areas are discussed in later paragraphs.

g. Total Pumping Requirements. The following was considered as a possible general criterion for the required pumping capacity for this project: to provide pumping capacity for maximum storm rainfall to be expected once in 10 years, plus allowances for sanitary sewage and dike seepage, with the river surface at the stage to be expected concurrently with the 10-year maximum rainfall. On this basis, the

pumping requirements for the Lakeview section would be 286 c.f.s. for storm run-off plus 2 c.f.s. for sanitary sewage plus 3 c.f.s. for dike seepage, a total of 291 c.f.s. Since this capacity is greater than the limiting capacity of the sewers (240 c.f.s., see paragraph 5a.(1)), the foregoing criterion could not be applied. It was decided, therefore, to provide pumping capacity at the maximum head equal to the limiting capacity of the sewers plus an allowance for dike seepage. This amounts to 243 c.f.s. (109,000 g.p.m.) at 21-foot static head for the Lakeview section. Similarly, in the Rosemont section the theoretical required capacity amounted to 117 c.f.s., whereas the limiting capacity of the trunk sewer on Beaver Street is 24 c.f.s. The four small sewers in this area are more than adequate for the run-off (10 c.f.s.) to be expected from their portion of the drainage area. It was decided, therefore, to adopt the pumping capacity at the maximum head equal to the limiting capacity of the main sewer (24 c.f.s.) plus the theoretical required capacity for the four small sewers (10 c.f.s.) plus the allowance for dike seepage (1 c.f.s.), a total of 35 c.f.s. On this basis, the required pumping capacity for the Rosemont section amounts to 16,000 g.p.m. at the maximum static head of 21 feet.

6. Engineering Features.- a. Surveys. Topographic surveys were made in this vicinity before and after the channel improvement work described in paragraph 4a. These data are satisfactory for preliminary planning of the structures now proposed and for estimating the extent of the spoil fill deposited on the site.

b. Exploration. The subsurface conditions of the sites have been explored with 7 borings and 5 test pits. The locations of these investigations and a description of the materials encountered in the borings are given on Plates 4 and 5.

c. Foundation Conditions. The general conditions of the foundation below the recent fill from channel excavation are fairly uniform. To the depths explored, the foundation is composed of three distinct deposits: (1) an upper zone of artificial fill and silty fine to medium sand ranging in depth from 13 to 20 feet and generally extending to the level of the normal water surface of the river; (2) an intermediate 5 to 8-foot stratum of loose, gravelly, fine to coarse sand; and (3) an underlying deposit of slightly clayey silt of undetermined thickness, but into which the borings were extended from 3 to 9 feet. The permeability of the upper zone is estimated to be less than 10×10^{-4} cm/sec. and the permeability of the gravelly fine to coarse sand to range from 50 to 100×10^{-4} cm/sec. The silt deposit is highly impermeable. The existing spoil bank, which will be adapted to form the bulk of the proposed dike section, is composed of an exceedingly variable and generally unsorted mixture of sand, gravel, and rock fill which, because of its artificial and variable nature, must be regarded as highly permeable throughout.

d. Description of Lakeview Structures. The protective structures for the Lakeview section will extend between the Aiken and Bridge Street bridges, a distance of 3,600 feet, and will consist of improvement of the existing spoil bank for 2,700 feet and construction of 900 feet of sheet piling wall bordering Front Street where space for a dike is not available. The plan, profile, and typical sections of these structures are shown on Plate 4. The river slope of the spoil bank will be excavated to a slope of 1 on 1-1/2 to a depth of 4 feet into the fine sand of the original foundation. A 3-foot blanket of impervious silty and gravelly sand obtained from borrow pits located within a hauling distance of 2 miles will be placed against the excavated slope of the spoil bank and the spoil will be replaced and graded off to a slope of 1 on 3 to protect the blanket from erosion. Foundation and surface drainage on the landside will be provided where required. Drainage wells consisting of 2-inch diameter well points spaced 15 feet on centers will be extended into the coarse sand stratum and will be connected to a perforated metal pipe drain laid in gravel backfill and leading to the pump station. In addition, the ground level behind the dike will be filled where required to reduce the effective head on the structure to a maximum of 5 feet. These provisions are believed adequate, (1) to prevent failure by piping, (2) to effectively reduce seepage through the spoil banks, (3) to prevent transfer of seepage water through the coarse stratum to the basements of buildings bordering Lakeview Avenue, and (4) to collect local surface water. The sheet piling wall will extend 5-1/2 feet above the adjacent street level and will penetrate into the impervious silt stratum over the full length of the wall. The wall will be suitably capped with a structural steel channel and will be caulked and painted to a depth of several feet below the ground surface. The removal, by local interests, of a portion of a frame store building fronting on Bridge Street will be required to provide room for connection of the wall to the abutment of the Bridge Street bridge.

e. Description of Rosemont Structures. The protective structures for the Rosemont section will consist of an improved spoil bank extending from Beaver Street downstream a distance of 1,000 feet to a broad abutment of filled land and a sheet piling wall extending from Beaver Street upstream along Beaver Brook a distance of 800 feet to a natural abutment. The plan, profile, and typical sections of these structures are shown on Plate 5. The spoil bank will be provided with a riverside impervious blanket and with landside drainage and backfill provisions generally corresponding to those described for the Lakeview section. A berm of fill will be placed on the landside of the sheet piling wall to reduce the effective head to a maximum of 6 feet. Because of this provision and the fact that the coarse stratum lies at a greater depth (23 feet below the average ground surface) the length of sheet piling used will be governed only by the requirements for stability, with no attempt to intercept the coarse zone completely. A concrete bulkhead will be constructed at Beaver Street with provisions for the installation of stoplogs to a height of 8 feet above the street.

f. Drainage and Pumping. (1) Lakeview Section. The existing city sewers and outlets and the proposed interceptor sewer to be constructed by the city of Lowell leading to a central pumping station are shown on Plate 4. The pumping station will have the required capacity of 109,000 g.p.m. at the maximum static head of 21 feet, which is equivalent to the maximum capacity of the sewers plus an allowance for dike seepage and corresponds to an average run-off from the 860-acre tributary area of 0.28 inch per hour. The pumping equipment will consist of 3 engine-driven 36-inch vertical propeller type pumps and one 16-inch volute pump.

(2) Rosemont Section. The existing city sewers and outlets and the proposed interceptor sewer to be constructed by the city of Lowell leading to a central pumping station are shown on Plate 5. The pumping station will have the required capacity of 16,000 g.p.m. at the maximum static head of 21 feet, which is equivalent to the maximum capacity of the sewers plus an allowance for dike seepage and corresponds to an average run-off from the 70-acre tributary area of 0.5 inch per hour. The pumping equipment will consist of 2 engine-driven 20-inch vertical propeller type pumps and one 6-inch volute pump.

7. Cost Estimates.- a. Lakeview Section.

<u>Item</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
<u>Sheet Piling Wall</u>			
Steel Sheet Piling	31,500 s.f.	\$ 1.25	\$ 39,400
Structural Steel (capping)	24,300 lbs.	0.12	2,900
Backfill	lump sum	-	600
Miscellaneous (painting, etc.)	lump sum	-	1,000
<u>Embankment</u>			
Common Excavation	24,600 c.y.	0.40	9,800
Trench Excavation	3,100 c.y.	0.80	2,500
Impervious Fill	9,800 c.y.	0.80	7,800
Dumped Fill	27,000 c.y.	0.55	14,900
Gravel Drain	2,600 c.y.	2.50	6,500
Seepage Pipe	1,360 l.f.	2.00	2,700
Drain Wells	91	34.00	3,100
Grading and Seeding	lump sum	-	2,500
<u>Pumping</u>			
Pumping Station (109,000 g.p.m.) . .	lump sum	-	100,000
Discharge Conduit	lump sum	-	5,000
Sub-Total			\$198,700
Engineering, Inspection, Overhead & Contingencies (35%+)			69,300
TOTAL CONSTRUCTION COST - LAKEVIEW SECTION			\$268,000

b. Rosemont Section.

<u>Item</u>	<u>Quantity</u>	<u>Unit Cost</u>	<u>Cost</u>
<u>Sheet Piling Wall</u>			
Steel Sheet Piling	14,800 s.f.	\$ 1.25	\$ 18,500
Structural Steel (capping)	18,500 lbs.	0.12	2,200
Backfill	2,000 c.y.	0.55	1,100
<u>Embankment</u>			
Common Excavation	4,800 c.y.	0.30	1,400
Trench Excavation	6,400 c.y.	0.60	3,800
Impervious Fill	5,900 c.y.	0.80	4,700
Random Fill (blanket)	3,400 c.y.	0.60	2,000
Dumped Fill	2,700 c.y.	0.45	1,200
Gravel Drain	900 c.y.	2.50	2,300
Steel Sheet Piling Cut-off	1,300 c.y.	1.25	1,600
Seepage Pipe	700 l.f.	2.00	1,400
Drain Wells	46	37.00	1,700
Disposal of Waste Material	3,000 c.y.	0.25	800
Grading and Seeding	lump sum	-	2,000
Bulkhead	lump sum	-	6,000
<u>Pumping</u>			
Pumping Station (16,000 g.p.m.) . . .	lump sum	-	34,000
Sub-Total			\$ 84,700
Engineering, Inspection, Overhead & Contingencies (35% <u>+</u>)			29,300
TOTAL CONSTRUCTION COST - ROSEMONT SECTION			\$114,000
TOTAL ESTIMATED FEDERAL COST - BOTH SECTIONS			\$382,000

8. Economic Study.- The total carrying charges for the construction work as outlined above, for both the Lakeview and Rosemont sections, together with the estimated charges on the required contribution of local interests for interceptor sewers and lands and rights-of-way (see paragraph 9, following), amount to about \$22,000 annually. The monetary value of tangible direct and indirect benefits of the proposed work amounts to \$18,000 annually. It is believed that these monetary benefits, together with the intangible value of the proposed work, such as the assurance of complete flood protection and possible enhancement of values, are sufficient to justify the project.

9. Local Cooperation.- a. Views of Local Interests. A public hearing was held in Lowell, Massachusetts, on November 21, 1938, in connection with the preparation of a report on the Merrimack River for

navigation, flood control, and water power authorized by the River and Harbor Act approved June 20, 1938. At this hearing, as well as subsequent conferences with city officials, local interests have urged local flood protection measures in the city of Lowell and particularly in the two sections in the city covered by this project.

b. Extent of Local Cooperation Required. Section 3 of the Flood Control Act approved June 22, 1936, applies. Local interests will be required to furnish all lands, easements, and rights-of-way necessary for the construction of the project and to furnish interceptor sewers to the pumping plant proposed for each section of the work. The estimated cost to local interests for these items is \$70,000 for the Lakeview section and \$20,000 for the Rosemont section.

c. Assurance of Local Cooperation. The city of Lowell, by official action of the city council on October 15, 1940 and of the mayor, on October 16, 1940, has furnished the necessary assurance that the city will: (1) furnish, without cost to the United States, all lands, easements, and rights-of-way necessary for the project, including sites for the structures, borrow pits, spoil disposal areas, and access roads; (2) assume the cost of relocating and reconstructing sewer lines, highways, buildings, or other structures as may be required; (3) hold and save the United States free from all claims for damages due to the work, and (4) maintain and operate the project without expense to the United States, in accordance with regulations prescribed by the Secretary of War.

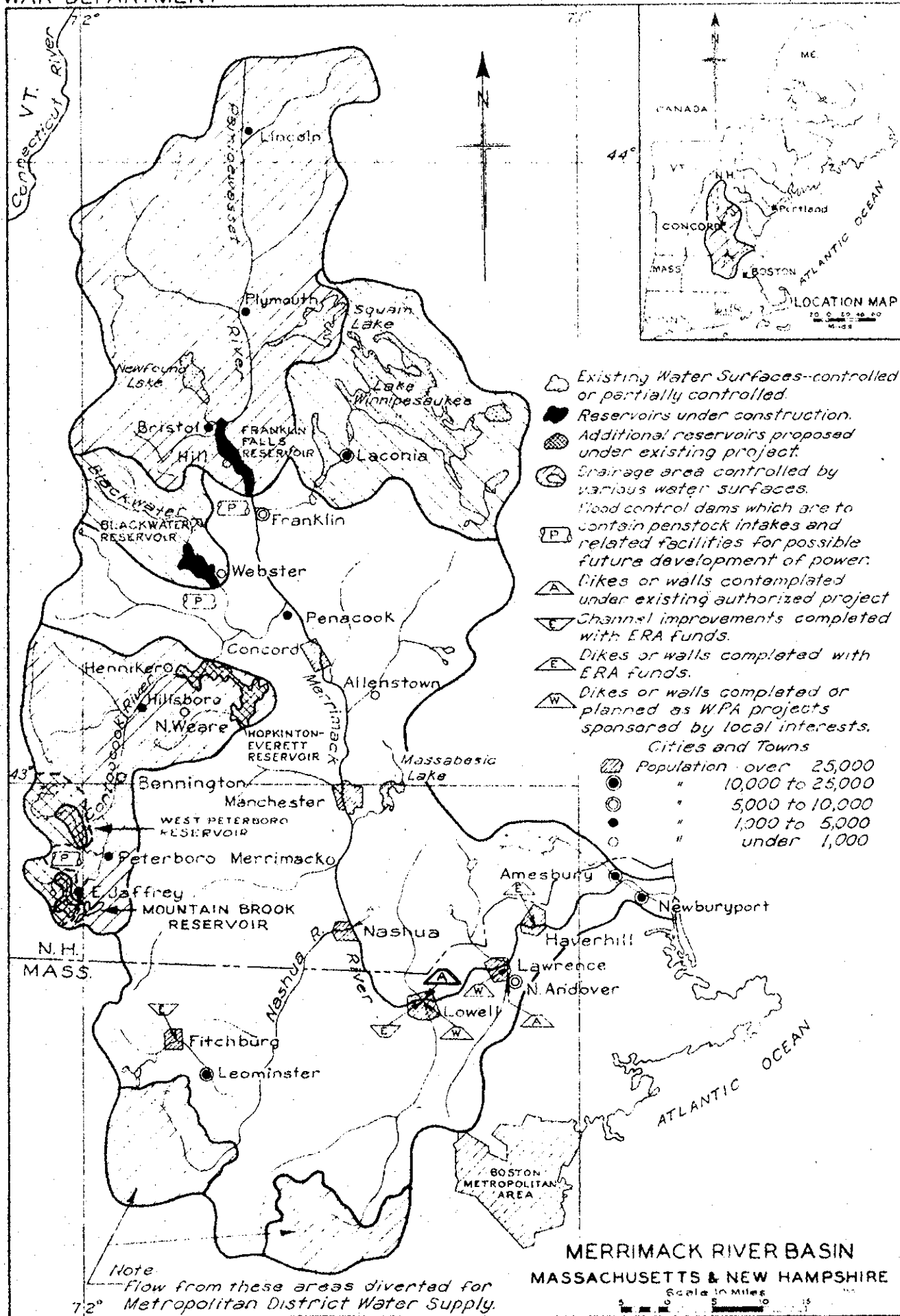
10. Time Required for Construction.- It is estimated that the work proposed herein can be completed in one construction season.

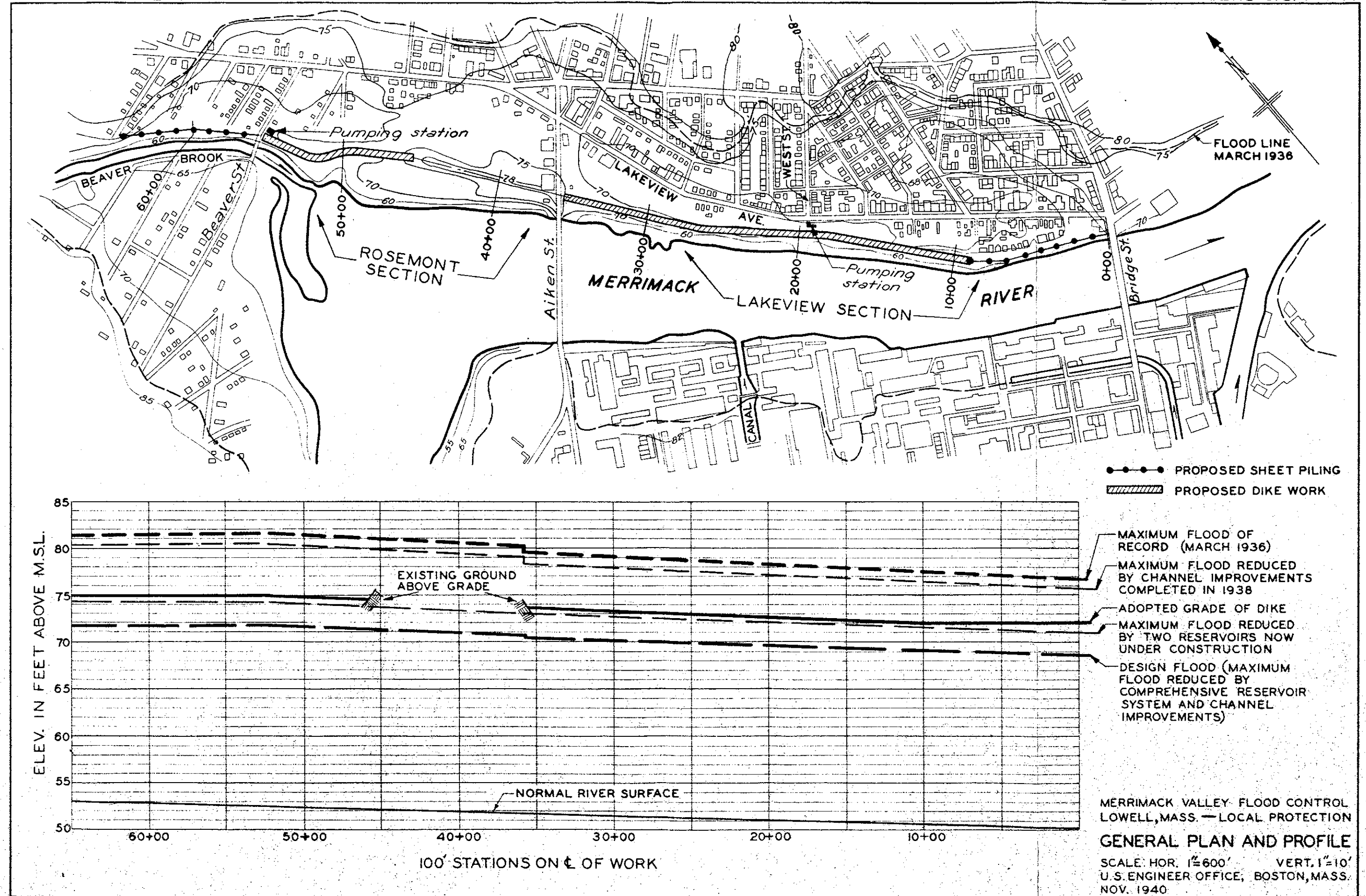
11. Recommendation.- It is recommended that the local flood protection work proposed herein, at an estimated cost to the United States of \$382,000, be selected as a definite project under the comprehensive plan for reservoirs and related flood control works for the Merrimack River Basin as authorized by the Flood Control Acts of 1936 and 1938.

L. B. Gallagher
Lieut. Col., Corps of Engineers
District Engineer

Inclosures:

- Plate 1 - Merrimack River Basin
- " 2 - General Plan and Profile
- " 3 - Drainage Area
- " 4 - Plan, Profile and Sections - Lakeview Section
- " 5 - Plan, Profile and Sections - Rosemont Section





CORPS OF ENGINEERS U.S. ARMY

932

BEAVER BROOK

Beaver St.

Aiken

MERRIMACK RIVER

West St.

Bridge St.

A

B

C

D

E

F

G

100

120

140

160

180

200

240

280

68

70

75

80

100

120

140

160

180

200

240

280

1000 0 1000 2000

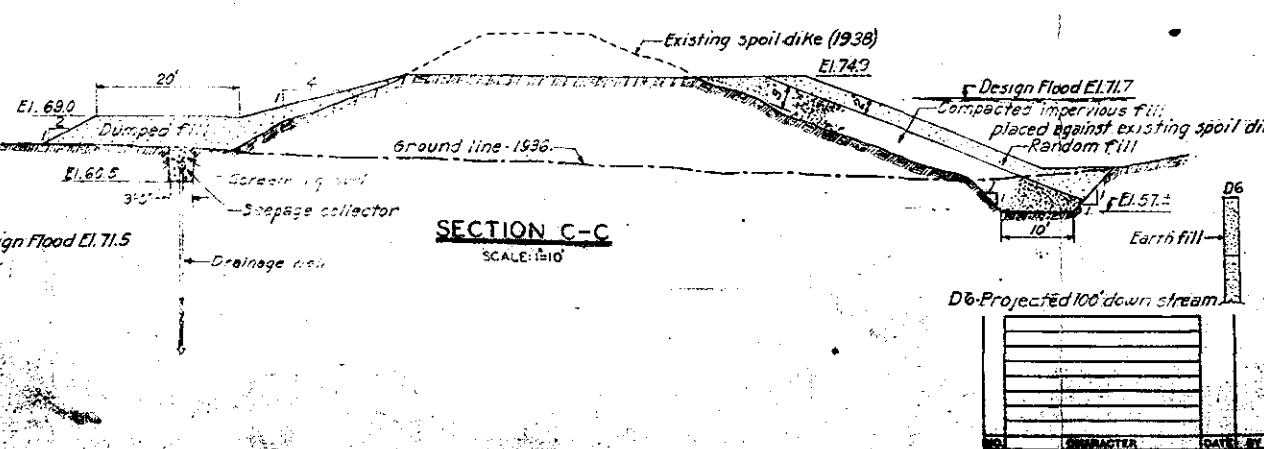
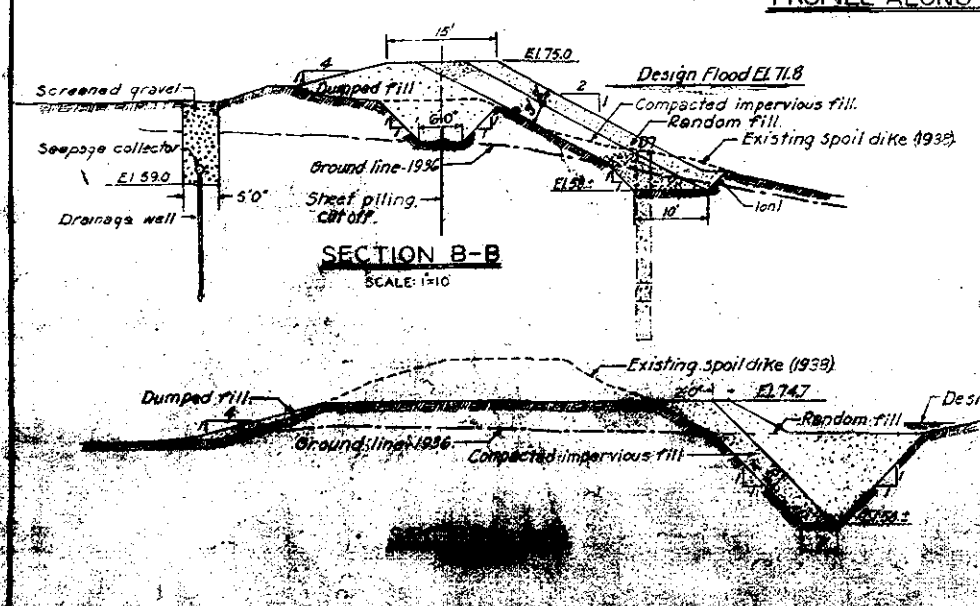
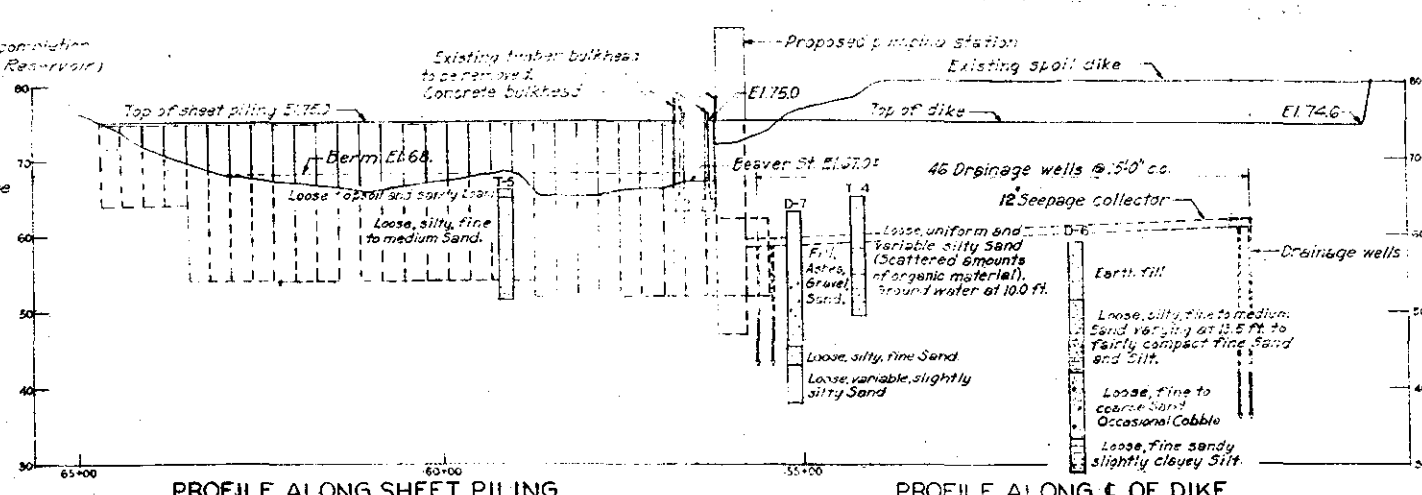
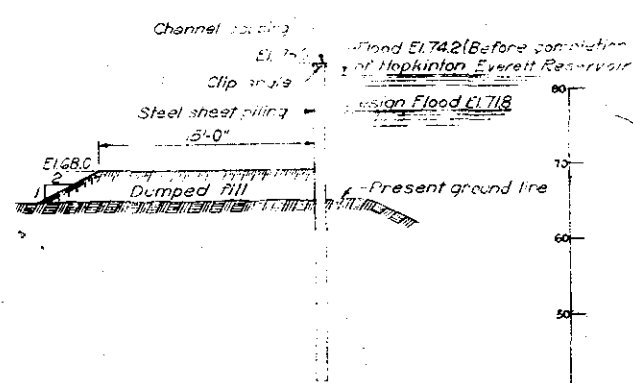
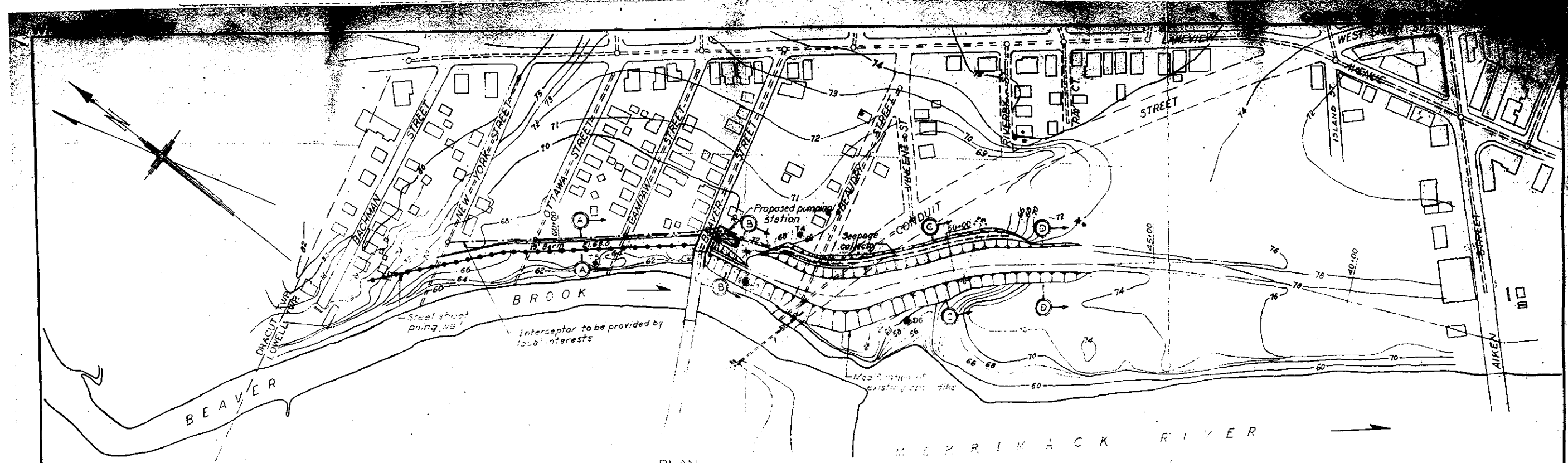
SCALE IN FEET

MERRIMACK VALLEY FLOOD CONTROL
LOWELL, MASS.—LOCAL PROTECTION

DRAINAGE AREA

U.S. ENGINEER OFFICE BOSTON, MASS.
NOV. 1940

PLATE 3



Note: Toe trench for impervious fill to extend not less than 4'-0" into fine sand. --- Existing sewers.

MERRIMACK VALLEY FLOOD CONTROL
MERRIMACK RIVER-BEAVER BROOK
LOCAL PROTECTION-LOWELL, MASS.
ROSEMONT SECTION
PLAN, PROFILE & SECTIONS
 IN 1 SHEET SHEET NO. 1 SCALE: 1"=100 FT.
 U. S. ENGINEER OFFICE, BOSTON, MASS. NOVEMBER, 1940
 APPROVAL RECOMMENDATION: _____
 REVISIONS: _____
 FILE NO. M54-1234